Defense Nuclear Facilities Safety Board Recommendation 2002-1
Software Quality Assurance Implementation Plan

Safety Related Design Software Survey and Recommendations

Interim Report

U.S. Department of Energy
Office of Environment, Safety and Health
1000 Independence Ave., S.W.
Washington, DC 20585-2040

December 2003

INTENTIONALLY BLANK

FOREWORD

This document provides the results of a Department of Energy Complex survey on safety related design software. Together with the survey responses, contained as a second volume to this report, the documentation meets IP commitment 4.2.1.5 to *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2002-1*.

Suggestions for corrections or improvements to this document should be addressed to:

Chip Lagdon
EH-31/GTN
U.S. Department of Energy
Washington, D.C. 20585-2040
Phone (301) 903-4218
Email: chip.lagdon@eh.doe.gov

INTENTIONALLY BLANK

REVISION STATUS

Page/Section	Revision	Change
1. Entire Document	1. Interim Report	1. Original Issue

INTENTIONALLY BLANK

CONTENTS

TABLES

INTENTIONALLY BLANK

Safety-Related Design Software Survey and Recommendations

EXECUTIVE SUMMARY

The Department of Energy (DOE) Implementation Plan (IP) for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2002-1, *Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities,* identifies a series of actions and commitments that address DOE's Software Quality Assurance (SQA) programs and activities. Commitment 4.2.1.5 addresses the conduct of a survey of safety-related design software currently in use to determine if any design code should be included as part of the DOE Safety-Related Toolbox. This report contains the results and recommendations of the design software review.

Thirteen organizations at ten DOE sites provided input to the design code survey. The National Nuclear Security Administration (NNSA) and DOE Program Offices, including Environmental Management (EM), manage these organizations and sites. The survey duration was from September to December 2003. Therefore, the survey information represents a snapshot in time of design code usage. Because some sites and organizations did not respond to the survey, the design software information may not be all-inclusive. Nevertheless, the information is complete enough to provide general trends and characteristics on design codes.

The survey information was grouped into seven major categories representing design areas including civil/structural/geotechnical, mechanical, and fire protection. Fifteen design codes were identified as being used at multiple sites or by multiple organizations. They are labeled as "multiple use" design codes and are described in this report. Use of software that is used by a single organization or site is acceptable depending on the SQA status of the software, appropriateness of the software for a given application, and user training.

However, the fifteen design codes are not designated for the toolbox, which currently contains six safety analysis codes. The design codes are proprietary, and are developed and maintained externally to DOE. In addition, these codes are used widely in many industries throughout the world. Most of the vendors/developers of these codes maintain their own SQA programs to correct errors and defects, and to provide notices and upgrade information to users, in order to be competitive with other vendors of similar design software.

Instead of using the toolbox approach, the DOE Office of Environment, Safety and Health (EH) will establish a web-based information system to maintain and centralize the developer-user interface, and streamline the SQA process. DOE users will be invited to interactively supply user interface and other DOE application specific information to the web-based information system. The web-based information system will be a primary mechanism to share the vendors' design software information, notices and upgrades and to report software errors and defects. Users are still responsible for assuring that their specific design software falls within the appropriate SQA plan at their sites or organizations, and that the SQA plan is implemented properly for the specific software and specific application.

INTENTIONALLY BLANK

1.0 Introduction

In January 2000, the Defense Nuclear Facilities Safety Board (DNFSB) issued Technical Report 25, (TECH-25), Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities (DNFSB, 2000). TECH-25 identified issues regarding computer software quality assurance (SQA) in the Department of Energy (DOE) Complex for software used to make safety-related decisions, or software that controls safety-related systems. Instances were noted of computer codes that were either inappropriately applied, or were executed with incorrect input data. Of particular concern were inconsistencies in the exercise of SQA from site to site, and from facility to facility, and the variability in guidance and training in the appropriate use of accident analysis software.

Progress was made in the 2000 to 2002 period assembling the basic elements to a response plan and collected data from DOE field offices and safety contractors on SQA programs and processes. However to expedite implementation of corrective actions in this area, the DNFSB issued Recommendation 2002-1, Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities, (DNFSB, 2002). As part of its Recommendation to DOE, the DNFSB enumerated many of the points noted earlier in TECH-25, but noted specific concerns regarding the quality of the software used to analyze and guide safety-related decisions, the quality of the software used to design or develop safety-related controls, and the proficiency of personnel using the software.

A series of actions that address the DNFSB's concerns are documented in the DOE Implementation Plan for DNFSB Recommendation 2002-1, Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2002-1, (DOE, 2003). The Implementation Plan (IP) was accepted by the DNFSB in April 2003 as adequately addressing the concerns raised by Recommendation 2002-1. The IP includes a commitment (4.2.1.5) to conduct a survey of design codes currently in use to determine if any should be included as part of the toolbox codes.

The toolbox codes are a small number of standard computer models (codes) supporting DOE safety analysis that have widespread use and appropriate qualification. Generally, the toolbox codes will have been developed and maintained within the DOE Complex. However, the toolbox concept may also include commercial or proprietary grade software typically applied for design purposes. In this case, DOE may consider additional SQA controls appropriate for repetitive use of the software in safety applications.

The scope of the survey required by commitment 4.2.1.5 includes the identification of safety software currently use to support the analysis and design of defense nuclear facilities including structures, systems and components, as well electrical and control system design. The survey requested identification of both commercial off-the-shelf (COTS) software and DOE/contractor developed software, as well as other industry sources. Often the same software is used for both safety and non-safety applications, and nuclear and non-nuclear facility design.

1.1 Objectives and Content of Report

This report supports completion of the commitment (4.2.1.5) by:

- Providing the results of a survey of the design codes currently in use in the DOE Complex
- Determining if any of the identified design software should be included as part of the toolbox.

The balance of this report includes discussion of the "Survey of Safety Software Used in Design of Structures, Systems, and Components". The results and trends identified from the survey are covered next. Contrasts between the multiple-use design software and the multiple-use safety analysis software previously identified (DOE, 2002) are then highlighted, before proposing a strategy for maintaining software quality assurance among the design software. Following this discussion, a practical approach is provided for addressing other widely used categories of software commonly used in engineering and safety analysis, i.e. General Use and commercial-off-the-shelf software. The document continues with recommendations and lessons learned from the survey and interpretation process, before developing a set of conclusions on design-related safety software in light of DNFSB Recommendation 2002-1.

A second volume to this report contains the full set of responses from DOE field offices and safety contractors.

1.2 Scope

The scope of this report is limited to the safety related design codes as used within the Department of Energy.

1.3 Purpose

The purpose of this report is to document a survey of safety related design codes as used in the Department of Energy sites and laboratories to determine if any should be designated as toolbox codes and placed in the Central Registry.

1.4 Methodology for Survey

A safety-related design code survey was developed by DOE to identify multiple use software among the various sites and laboratories in late summer of 2003. The survey was based on an earlier solicitation made to identify safety analysis and instrumentation and control (I&C) software, but tailored to meet current requirements for information to support the IP. A secondary goal was to review the various programs, practices, and procedures used to assure software quality in the design software area among site contractors.

The "Survey of Safety Software Used in Design of Structures, Systems, and Components" was finalized and was transmitted to primarily NNSA and EM sites on 12 September 2003. The survey first requested identification of the principal DOE office(s) that the contractor supported.[1]

Software used in seven categories was solicited, including

- Civil/Structural/Geotechnical Systems
- Mechanical Systems
- HVAC
- Electrical Systems
- Fire Protection Systems
- Instrumentation and control
- Other categories.

For each computer code identified, the inputs to Table 1-1 were requested.

A final optional, section to the survey requested input on the contractor SQA programs, procedures, and training, and the SQA standards or DOE directives that are met in terms of compliance.

In terms of timing, the survey was in effect a snapshot of the design software used throughout the DOE Complex for safety purposes in the September – December 2003 period. It was anticipated that nearly all the software used for design purposes would be commercial grade and proprietary.

[1] Secondary release of the survey also included Office of Civilian Radioactive Waste Management, Office of Science and Office of Nuclear Energy sites.

Table 1.1 Design Software Information Requested in Survey

a.	Code name and version
b.	Function of code
c.	Application (what projects/facilities at the site/lab)
d.	Code developer and/or sponsor
e.	Commercial, Proprietary or Other (Explain)
f.	Current Owner/Vendor and technical support provider
g.	Documentation available
h.	Code platform (Workstation, PC-based, Mainframe)
i.	Operating System (Windows, DOS, other)
j.	Frequency of Use (Routine, repeated use, code of choice – R; Occasional use – O;)
k.	How are error and user questions reported?
l.	Comments on experience with this computer software, ease of application, documentation provided; known errors or issues

2.0 Survey Results

This section presents the survey results.

This survey identified over seventy codes being used as safety-related design software at Department of Energy sites. Table 2.1 presents the results of the survey in tabular form. The rows correspond to the codes identified and are sub-grouped into one of seven use categories. The use categories are Civil, Mechanical, HVAC, Electrical, etc. The columns of Table 2.1 correspond to the site or organization that supplied the survey information.

Table 2.1 Survey Results –Category vs. Site/Organization

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
1. Civil/	ABAQUS	None							ABAQUS 6.3	ABAQUS			ABAQUS
Structural/	SHAKE91						SHAKE 2000			SHAKE91			
Geotechnical Systems	GTSTRUDL						GTSTRUDL Version 25						
	SASSI						SASSI 2000			SASSI			SASSI
						SAP2000				Sap 2000 NL			SAP2000 Plus
								COSMOS	COSMOS 2.9				
										RISA3D			RISA3D
						ANSYS/ Mech. Version 7.0	ANSYS	ANSYS		ANSYS V7.1	ANSYS V7.1		ANSYS
	SRPP				Nonlinear		CE928 (DATAN), 1991	Flex PDE		BlastX	BlastX V4.2		WaterCAD
							Compress 6.187/6.214	Ansoft Mawell 3_d		ETABS NL	STADD Pro 2003		VAM3DF

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
					ALGOR		CE980 (BSIMQKE),1984	LS-DYNA and LS-POST		PSADS	MSC MARC 2003, Dytran 2002, Nastran 2003		SAP Nonlinear
										SAFE	Pro-Engineer 2001		
2. Mechanical Systems	AutoPIPE Plus	None	None			AutoPIPE				AutoPipe Plus 6.3			AutoPipe
									COSMOS 2.8	COSMOS /M 2.6			
							Pipe-Flo Professional Version 7.0						Pipe-Flo
	ANSYS										ANSYS 7.1		
	ABAQUS						HTRI (IST 2.0) (PHE 2.0)						
	MSC/THERMAL						FLUENT			DESIRE 2000			

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
	Type II, III, & IIIA Tank Top Load,				ALGOR		Aspen BJAC 11.1	FLUENT/ GAMBIT		AFT Fathom 5.0			
	Type 1 Tank Top Load						Pipe-Flo compressible Version 7.0						
							DAPSS 1.0						
							Jet Impingement Code (NE155)						
							Compress 6.187/6.214						
							B31.3/Multiple Mes & versions						
3. HVAC	None	None	NONE			GOTH-SNF	FLUENT				Trace 700 V4.0		

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
4. Electrical Systems	PDMS	None	None				AGI32 Version 1.64	PTW			SKM Power Tools		
	ETAP						ETAP POWERSTATION 4.7.0						
							EA399/Setroute Version 8.7.1.1						
5. Fire Protection	HASS		HASS		HASS		HASS 7.5			HASS	HASS		HASS
	Pipe2000		FAST										
	KYPIPE												
	NIST Fire Dynamic Simulator and SmokeView												

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
6. Instrumentation and Control	None	None	None		DMT		Control Valve Sizing - Gas Service Version 1.1						
					ARCS		Control Valve Sizing - Liquid Service Version 1.1						
							Control Valve Sizing - Steam Service Version 1.1						
							FLOWEL, Version 3.0g						
7. Other Design Software					Micro-Shield	Micro-Shield 6.01	Micro Shield 6.0.1						

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
	VERSE-LC	None	RADIDOSE				Process Perf. SW 1.0		Integrated Tiger Series V5.0				
							WTP Engr. Baseline		ANITA V2000				
							HSC Chemistry 4.1		CINDER V90				
							Delmia Envision Version D5R12 (IGRIP)		DKPOWR				
									PARTISN V2.9				
									ADEPT				
							winnUPRA Version 2.0		SCALE V4.4A				
8. Other Software- Not Recommended As Design							MATHCAD 11			MATHCAD			MATLAB
							Mathematica			MASS			

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
							MCNP 4C	MCNP ORIGEN	MCNP V5.0	MCNPx, MCNP-4C	MCNP 4A,4B,4C,5 AND X		
		ALGEBRACDB,BLOTCDB,BRAGFLO,CCD2STEP,….etc.[1]								Transient Combustible EXCEL Spdsheet V2.1	SOURCES-4C		
		RadClient/Radnet								MAR Summary 032701 V1.0.0.1	TWODANT		
		CFAST								CFAST/FAST 5.013.1.7,2.01			
										SANET			
		GXQ								POSTMAX2	NARAC		
		Lpu02ab.exe								SeaTREE	SAFER V.202		
		Lpu02af.exe								FDS2	MSC Patran 2003		
		MetData Application								ERAD 3.2	ERAD		

	Table 2.1												
Category	**Site/Organization**												
	SRS	**WIPP**	**Rocky Flats**	**Yucca Mtn Project**	**ANL-W**	**Hanford/ CH2M Hill**	**Hanford/ Bechtel National**	**Hanford/ Duratek**	**Sandia**	**LANL**	**Pantex**	**LLNL**	**DOE/Richland**
	CAMEO									CAMEOfm			
		CAP88-PC V1.0							MELCOR	AutoDesk AutoCad MARPLOT V3.3	MSC ADAMS 2003, Mvision SABRINA		
	ALOHA, HOTSPOT	GEN-II-s		MACCS2 Version 1.12					MACCS2	EPIcode 6.01,MACCS2,GENII 2, MELCOR, HOTSPOT 2.05, ALOHA V5.3.2	MACCS2, MELCOR, HOTSPOT 2.0, EPIcode 2.03, ALOHA	HOTSPOT V2.05	
										DANTSYS	KENO V & KENO-3D		
										SQ LIMS V3.1	VISUAL EDITOR		

Footnotes to Table
[1] Multiple codes used to model the performance of the WIPP repository, not used for safety.

Many of the computer codes identified in Table 2.1 are special use software, i.e., applicable to unique design or process requirements, or site-specific or site-developed codes used only at one site by one organization. These codes appear only once in Table 2.1.

Table A-1 (Appendix A) provides the same survey information as Table 2.1 but reorders the table to show site/organization by row and by category in the columns.

Many of the computer codes identified are used at more than one site or by more than one organization. There are fifteen codes used by more than one site or by multiple organizations with approximately half of these being in the Civil/Structural/Geotechnical category. These are listed in compact form in Table 2.2.

Table 2.2 Multiple Use Software Codes Identified

Survey of Design Codes - Multiple Use Codes				
Category	**Item**	**Code Name**	**Number of Sites**	**Number of Orgs.**
1. Civil/Structural/Geotechnical	1	ABAQUS	4	4
	2	ANSYS	4	7
	3	BlastX	2	2
	4	GTSTRDL	2	2
	5	RISA-3D	2	2
	6	SAP 2000	2	2
	7	SASSI	3	4
	8	SHAKE	3	3
2. Mechanical		ANSYS	4	7
	9	AutoPIPE	3	4
	10	COSMOS	2	2
	11	FLUENT	1	2
	12	PIPE-FLO	1	2
3. HVAC		FLUENT	1	2
4. Electrical Systems	13	ETAP	2	2
5. Fire Protection	14	HASS	6	7
6. Instrumentation and Control		none		
7. Other	15	MicroShield	2	3

Most of the computer codes listed in Table 2.2 are proprietary/commercial and tend to be widely used in a number of different industries and applications outside of the Department of Energy. The final two columns give a count of the number of sites where each code is used and the total number of organizations (regardless of being on the same site) using each code. For example, responses were received from Hanford from four different organizations, and in some cases, each organization used the same code.

Most codes are for application in specific disciplines of engineering design and used not only in the Department of Energy but also across a broad array of industries and applications. For example, ANSYS is used throughout the United States and internationally to perform structural analysis. PIPE-FLO is a general use code to analyze pressure drops and help design piping and pumping layouts in the chemical, nuclear, and other industries. FLUENT is a general use computational fluid dynamics code used in a broad array of applications ranging from assessing weir overflow in sanitary distribution systems to evaluating optimum geometry for computer drive heads. All of these computer codes have thousands of users in the United States and abroad.

Several respondents interpreted their use of a design code in what they judged as the most applicable category for use. For example, ANSYS is applied by several sites for mostly Civil/Structural/Geotechnical design while other sites view their application of the same code as mostly for Mechanical System design. Similarly, FLUENT is used in both Mechanical System and HVAC design applications.

The following sub-sections, 2.1 – 2.7, describe the multiple-use software. A listing of the Area of Applicability is given along with a summary description of the software. Contact information, SQA-related discussions, and training information for each computer code are found in Appendix B. The contact information includes the website address, as well as phone numbers and email information when provided on the website as of December 2003. The synopsis of each code's quality assurance is based primarily on information gleaned from the website associated with the code, or based on information that could be gathered from the web. There is very likely additional information that a vendor could provide on request to prospective users.

The fifteen multiple-use code websites provide varying levels of discussion on SQA and related verification and validation programs associated with the development and maintenance of their software. Several point to ISO 9000 or 9001 certification, while others are said to be compliant with 10 CFR 50 Appendix B or applicable parts of ASME NQA-1. A small number of these codes are relatively silent on how they formally address and maintain quality assurance in their software

2.1 Civil/Structural/Geotechnical Engineering Design Applications

Software identified in this area of applicability includes ABAQUS, ANSYS, BlastX, GTStrudl, RISA-3D, SAP2000, SASSI, and SHAKE. Refer to Tables B-1 through B-8 for more information.

2.1.1 ABAQUS

ABAQUS provides solutions for linear, non-linear, explicit and multi-body dynamics problems to deliver a unified finite element analysis environment. The ABAQUS suite consists of three core products - ABAQUS/Standard, ABAQUS/Explicit and ABAQUS/CAE. Each of these packages offers additional optional modules that address specialized capabilities some customers may need.
ABAQUS/Standard®, provides ABAQUS solver technology to solve traditional implicit finite element analyses, such as static, dynamics, thermal, all powered with the widest range of contact and nonlinear material options. ABAQUS/Standard also has optional add-on and interface products with address design sensitivity analysis, offshore engineering, and integration with third party software, e.g., plastic injection molding analysis.
ABAQUS/Explicit®, provides ABAQUS solver technology focused on transient dynamics and quasi-static analyses using an explicit approach appropriate in many applications such as drop test, crushing and many manufacturing processes.
ABAQUS/CAE®, provides a complete modeling and visualization environment for ABAQUS solvers. With direct access to CAD models, advanced meshing and visualization, and with an exclusive view towards ABAQUS solvers, ABAQUS/CAE is the modeling environment of choice for ABAQUS solvers.

2.1.2 ANSYS

ANSYS is structural analysis software. Its structural models have a full complement of nonlinear elements, nonlinear and linear material laws, and inelastic material models. ANSYS simulates the largest and most intricate of structures. Its nonlinear contact functionality allows for the analysis of complicated assemblies. ANSYS offers users an intuitive, tree-structured GUI for easy definition of even the most intricate material models and a choice of iterative and direct solvers for optimal. ANSYS mechanical models include a full complement of nonlinear and linear elements, material laws ranging from metal to rubber, and a comprehensive set of solvers. The mechanical models can handle complex assemblies—for example, those involving nonlinear contact—and can used for determining stresses, temperatures, displacements and contact pressure distributions on component and assembly designs.

2.1.3 BlastX

BLASTX is a code developed by the Army Corps of Engineers Energy and Research Development Center that calculates blast overpressure. It accurately computes both the positive and negative phases of the shock wave. BLASTX (version 3.0) code calculates the propagation of blast shock waves and detonation product gases in multi-room structures. The code provides predictions of the pressure-time and temperature-time histories in these structures. The 3.0 version includes: (1) a variety of room shapes that may be used throughout a structure, (2) an interactive menu-driven input module, (3) an enhanced version of the burning, venting, and wall-failure models from the Naval Surface Warfare Center INBLAST code, (4) failure models using the total shock and quasi-static gas pressure on a wall, (5) heat conduction to walls, (6) a more accurate model of shock propagation through openings, and (7) modeling of blast-effects within and outside of explosive storage magazines. The code uses dynamic memory allocation so that structures ranging from a single room to many rooms may be treated.

BlastX was the only non-commercial software of the fifteen multiple-use codes identified through the survey process.

2.1.4 GTStrudl

GT STRUDL is a Structural Design & Analysis software program for Architectural - Engineering - Construction (AEC), CAE/CAD, utilities, offshore, industrial and civil works. GT STRUDL is a fully integrated general- purpose structural information processing system capable of supplying an engineer with accurate and complete technical data for design decision-making.

GT STRUDL integrates graphical modeling and result display, frame and finite static, dynamic, and nonlinear analysis, finite element analysis, structural frame design, graphical result display, and structural database management into a menu driven information processing system.

2.1.5 RISA-3D

RISA-3D for Windows is a general purpose three-dimensional analysis and design program developed to make the definition, solution and modification of 3D problem data faster and more manageable. Complete hot rolled steel, cold formed steel, and wood design is included. Analysis, up to and including calculation of maximum deflections and stresses, may be done on structures constructed of any material or combination of materials.

RISA-3D is based on the widely accepted Linear Elastic Stiffness method for model solution. The stiffness of each element of the structure is calculated independently. These stiffnesses are then combined to produce the model's overall (global) stiffness matrix. This global matrix is then solved (versus the applied loads to calculate joint deflections.) These joint deflections are then used to calculate the individual element stresses. The dynamic analysis is performed using a subspace iteration procedure.

2.1.6 SAP2000

SAP2000 is a tool to provide three dimensional static and dynamic finite element analysis and design of structures. The intuitive interface allows creation of structural models rapidly and intuitively without long learning curve delays. Complex models can be generated and meshed with powerful templates built into the interface.

The advanced analytical techniques allow for step-by-step large deformation analysis, multiple p-delta, eigen and ritz analyses, cable analysis, tension or compression only analysis, buckling analysis, blast analysis, fast nonlinear analysis for dampers, base isolators and support plasticity, energy methods for drift control and segmental construction analysis.

2.1.7 SASSI

SASSI (a System for Analysis of Soil-Structure Interaction) was originally developed by a group of graduate students at the University of California, Berkeley. SASSI2000 is a package of interrelated computer programs that can be used to solve a wide range of dynamic soil-structure interaction problems in two or three dimensions. SASSI has been used by many engineering firms and other institutions for dynamic soil-structure interaction analysis. It is currently an industry standard for solving soil-structure interaction problems.

The seismic design of all standard nuclear power plants in the United States (ABWR, SBWR, AP600, and System 80+) and many of the older plants is based on the SASSI solution for generation of seismic responses. SASSI is increasingly used in other industries including transportation, petrochemical, and industrial facilities when subjected to dynamic loading.

2.1.8 SHAKE

SHAKE is software for equivalent linear seismic response analysis of horizontally layered soil deposits. It is developed and supported by the University of California. The SHAKE program has been a widely used program for computing the seismic response of horizontally layered soil deposits. The program computes the response of a semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves. The analysis is done in the frequency domain, and, therefore, for any set of properties, it is a linear analysis. An iterative procedure is used to account for the nonlinear behavior of the soils. The object motion (i.e., the motion that is considered to be known) can be specified at the top of any sub layer within the soil profile or at the corresponding outcrop.

Manuals source code and information can be found through the National Information Service for Earthquake Engineering, University of California, Berkeley.

2.2 Mechanical System Analysis

Software identified in this area of applicability includes ANSYS, AutoPIPE, COSMOS, FLUENT, and PIPE-FLO. Refer to Tables B-9 through B-12 for more information.

ANSYS was described earlier in section 2.1.1 and will not be repeated.

2.2.1 AutoPIPE

AutoPIPE is a computer aided engineering program for stress analysis of piping systems. AutoPIPE enables engineers to explore different alternatives for piping design and perform code compliance checks in a time and cost efficient manner. AutoPIPE contains a comprehensive and extensible library of material properties and piping components including pipes, reducers, tees, valves, flanges, flexible connectors and other items. It performs single and multiple spring hanger design for one or more operating conditions. The code performs linear or nonlinear static analysis of piping systems and their supports. The software's proven nonlinear algorithm solves complex problems containing gaps, friction, buried pipe, limit stops, and other piping configurations. Loading includes gravity, buoyancy, support displacements, point and distributed loads, thermal expansion, pressure thrust, equivalent static earthquake, wave, and wind loadings

2.2.2. COSMOS

COSMOSM™ is one of a series of COSMOS modules that offer a wide range of material properties and thermal analysis capabilities, including:
Modeling, meshing and visualization of parts as well as assemblies
Comprehensive analysis capabilities, stress, frequency, displacement, buckling, heat transfer, nonlinear, dynamic response and fatigue capabilities; and
Design optimization.

COSMOSM features an extensive library of 1D, 2D and 3D elements supports isotropic, orthotropic, anisotropic, multi-layer composite, and temperature-dependent material properties.

Capabilities include linear gap/contacts, stress stiffening, sub-structuring, multi-point constraints, constraint equations and more. COSMOSM can solve the computation of heat transfer due to conduction, including with convection and radiation boundary condition, for materials with isotropic, orthotropic, composite, and temperature-dependent properties. The code can also perform nonlinear analyses.

2.2.3 FLUENT

FLUENT is a computational fluid dynamics (CFD) code used to resolve a wide range of problems. It has unique capabilities as an unstructured, finite volume based solver. It is frequently coupled with pre-processing and post-processing software offered by the software developer. Some of its features include: Complete mesh flexibility; All speed regimes (low subsonic, transonic, supersonic, and hypersonic flows); Parallel processing; Solution-based mesh adaption; Steady-state and transient flows; Inviscid, laminar, and turbulent flows; Newtonian or non-Newtonian flows; Full range of turbulence models from simple k-epsilon models to large eddy simulation; Heat transfer including forced, natural, and mixed convection, conjugate heat transfer, as well as several radiation models; Chemical species transport and reaction, including homogeneous and heterogeneous combustion models and surface reaction models; Free surface, Eulerian and mixture multiphase models; Lagrangian trajectory calculation for dispersed phase modeling (particles/droplets/bubbles); Phase change model for melting/solidification applications; Cavitation model; Materials property database; Integrated problem set-up and post-processing; and Extensive customization via user-defined functions.

2.2.4 PIPE-FLO

PIPE-FLO is a piping system analysis tool. It can provide a picture of the entire piping system by integrating the following tasks into a single program: 1) A flow diagram interface showing how the system components and pipelines are connected, 2) A powerful calculation engine showing how the system operates, 3) Communication tools to share the design with others, 4)Links to supporting documents in electronic format.

PIPE-FLO draws a piping system schematic or FLO-Sheet showing all the pumps, components, tanks, control valves and interconnecting pipelines. It sizes the individual pipelines using electronic pipe, valve, and fluid data tables. It selects pumps and control valves from manufacturer's Electronic Catalogs, to optimize pump and system operation. PIPE-FLO calculates how the system operates including pressures and flow rates, net positive suction head, and annual operating costs. It creates FLO-Links to provide immediate access to supporting documents needed to design, build and operate the piping system. The user can share the piping system information with others by way of the PIPE-FLO Viewer.

2.3 HVAC System Analysis

Software identified in this area of applicability includes FLUENT.

2.4 Electrical Systems Analysis

Software identified in this area of applicability includes ETAP. Refer to B-13 for more information.

2.4.1 ETAP

ETAP PowerStation is a fully integrated electrical power system analysis tool. Over 50,000 engineers use PowerStation worldwide in the design, analysis, maintenance, and operation of electrical power systems. ETAP PowerStation offers a wide selection of modules including: panel systems, short-circuit, load flow, motor acceleration, transient stability, generator start-up, harmonic analysis, etc.

2.5 Fire Protection

Software identified in this area of applicability includes HASS. Refer to B-14 for more information.

2.5.1 HASS

HASS (Hydraulic Analyzer of Sprinkler Systems) was introduced in 1976 and has been upgraded annually. The code operates with all versions of Windows in English or metric units as well as metric units with Spanish text. Data entry features include a grid estimator, tree generator, system builder and utilities to develop equivalents for K-factors, branch lines, grids and fitting lengths. Other utilities calculate earthquake bracing, report flow results, analyze water hammer, and more. HASS calculates complex systems in seconds using either the Hazen-Williams or the Darcy-Weisbach formulas, with or without velocity pressure. HASS performs hydraulic analysis in accordance with NFPA 13, calculating any connection of nodes and pipes.

2.6 Instrumentation and Control Applications

No one software package was identified for I &C applications with more than one contractor. In most cases, the responses indicated that no commercial grade software is used for this purpose.

2.7 Other

Software identified in this area of applicability includes MicroShield. Refer to B-15 for more information.

2.7.1 MicroShield

MicroShield is a comprehensive photon/gamma ray shielding and dose assessment program being used by more than 500 organizations. It is widely used for designing shields, estimating source strength from radiation measurements, minimizing exposure to people, and teaching shielding principles. Its use requires a basic knowledge of radiation and shielding principles. It was originally developed by Grove Engineering, which was acquired by Framatome ANP.

3.0 Contrast to Safety Analysis Toolbox Software Codes

This section compares the six designated safety analysis codes with the multiple-use safety-related design software, as well general use analytical software. It then contrasts typical practice for using the design software with the use of safety analysis software.

3.1 Design Software

The design software listed in Table 2.2 is widely used outside of the DOE Complex, has been in use for many years, and in most cases, can be considered to have widespread acceptance and extensive user's groups. In general, their individual user communities are considerably larger than those for the designated safety analysis toolbox codes. Additionally, use of the safety-related design software tends to be industry-independent, typically spanning many sectors of engineering design. Finally, the design software is typically proprietary. Thus, commercial interests (competitive acceptance) create a dynamic for the software developer to identify and correct deficiencies or errors in a timely manner.

In contrast, the safety analysis toolbox software codes have relatively smaller user groups, and with the exception of EPIcode, are not proprietary. Thus, the competitive commercial incentive to maintain a comprehensive error identification and correction process does not exist. To address this shortcoming, the DOE established the toolbox software strategy as part of the Implementation Plan response to the DNFSB Recommendation. These safety analysis codes are thus supplemented with DOE published user guidance documents that establish the applicable usage, appropriate range of use and cautionary instructions to minimize the potential for inappropriate software applications.

Design software is usually used to establish the minimum structural or system details necessary to fulfill a SSC's design function(s). As such, there are established design methodologies, design requirements (i.e., building codes and standards) safety factors and construction techniques associated with the software use. These established protocols reduce the potential for software errors that result in unacceptable SSC performance. In addition, typical industry practice is to submit the design of critical SSCs to alternate verification (e.g., independent calculation or physical testing). This further reduces the potential for unacceptable SSC performance based on one specific computer analysis alone.

When used in a safety analysis context, the design software is commonly used to evaluate the actual safety margins that exist for an SSC. These safety margins are then used to judge if the selected safety class (SC) and safety significant (SS) controls are adequately robust. Thus, the design software usually does not have a direct affect on the stated DSA accident consequences. In this context, there is typically a high degree of independent technical confirmation that assures a robust analytical process.

The designated toolbox software are usually used to either estimate postulated accident conditions (e.g., CFAST) or the consequences (e.g., MACCS2). As such, predictions from safety analysis software are used directly in deriving the SC and SS controls. In addition, the safety analysis software predictions often are not subject to as robust an independent technical

confirmation by alternate calculation compared to design software applications. Rather, the software predictions are taken as valid if the software inputs and outputs are confirmed.

Since design software is typically proprietary, has widespread use, and does not have as direct a bearing on SSC determination and ultimately, DSA conclusions, the software quality assurance implementation process need not be as rigorous as proposed for the safety analysis toolbox software. As such, the critical SQA functions that DOE should address, independent of the software developer, are (1) a process for error identification, tracking, and correction, (2) adequate user training, and (3) incorporation of lessons learned.

A strategy to discuss how these SQA functions will be accomplished will be presented in Section 4.

3.2 Analytical Software

Another group of software reported in the survey, cannot be categorized as strictly design software or safety analysis software. It is more appropriately thought of as *analytical* software. Analytical software does not focus on any specific application, and is widely used outside of the DOE Complex throughout science, engineering, and business sectors. It is usually general-purpose, proprietary software used to solve a wide array of problems in design as well as other engineering areas. This software, of which MATLAB, MATHEMATICA, MATHCAD, and EXCEL are examples from the design software survey, is used directly without modification, and is commercial off-the-shelf in nature. Analytical software has been in use for many years and has even greater acceptance and extensive user base than safety-related design software. As with the design software, these characteristics are very different from the designated safety analysis toolbox software.

Because of their flexibility, analytical software cannot be readily demonstrated as adequate using a back-fit SQA process, based on the outcome of a gap analysis. In addition, such a process is usually not warranted since commercial interests ensure that a SQA process must exist. In addition, DOE sites have a QA program that controls the preparation of calculations. The site-specific QA program must include a requirement for independent review of all design products (10CFR830.122(f)). Thus, a centralized approach to SQA for analytical software is neither practical nor desirable. Rather the SQA for such software will be assured through existing site-specific QA programs.

While a formalized SQA effort related to analytical software is not warranted, it would be desirable to facilitate the sharing of information between software users and the publication of lesions learned. To accomplish this objective, provisions for a web-based information system will be made for the exchange of this information and is discussed in Section 4.

4.0 SQA Strategy

This section describes the proposed DOE strategies to address SQA for design and analytical software.

4.1 Strategy for Design Software

As discussed in Section 3, the infrastructure supporting the design software SQA is very different from that supporting the designated safety analysis toolbox software. Thus, upgrades to the DOE SQA program as defined in the IP must be adapted to reflect these realities. In essence, the current competitive dynamic existing among design software developers, and the proprietary nature of the multiple-use software will be used to focus the proposed DOE SQA strategy. Primarily, the DOE SQA program will assume that the developer of the design software has an adequate process to verify, test and control the software prior to its release. However, other aspects of a robust and mature SQA process must be present. DOE efforts will then focus to promote these areas by promoting the following:

- Reporting and tracking of errors and deficiencies
- Incorporation of lessons learned, and
- Adequate user training.

The reporting and tracking of errors and deficiencies will be accomplished through a DOE web-based information system. DOE design software users will be encouraged to report known errors through the web-based information system and encouraged to share lesions learned. Such an effort will contribute to, but not replace, adequate user training.

This centralized approach is expected to streamline the SQA implementation effort related to design software and reduce the likelihood of unrecognized errors affecting multiple projects. It is considered appropriate because the software is:

- widely used, thus the potential for unreported errors is low
- nearly all proprietary, thus the DOE influence to modify the existing SQA is limited
- subject to alternate reviews in the DSA development process.

This approach necessitates that each DOE software user:

- Identifies and justifies the version of design software being used
- Has been adequately trained
- Understands limitations of the software
- Uses inputs and assumptions that are consistent with the intent of the software, and the specific application.

4.2 Strategy for Analytical Software

Analytical software such as MATLAB, MATHEMATICA, MATHCAD, and EXCEL were identified in the survey (See table 2.1 and the category tilted: Other software not recommended as design). As noted earlier, these codes are general-purpose, proprietary software used to solve a wide array of problems in design as well as other engineering areas. Many of these codes are used directly without modification, and are commercial off-the-shelf in nature. This software is often used in simple ways to sum data as well as perform simple mathematical operations. The software of this category is also used for much more complex analysis including solving sets of differential equations, and programming complex conditional logic.

All of these codes are widely used. A huge number of users apply the codes to problems across many disciplines on a daily basis. Within the DOE Complex, these general use tools are fundamental tools for engineers and solve all sorts of design problems. Quality assurance for these types of codes presents a unique set of challenges.

Simple models or mathematical manipulations are documented easily and may be checked by hand calculations or with a calculator. Quality assurance in simple cases can be achieved by inspection.

More complex models present more of a challenge and can become equivalent to having designed an independent piece of software thereby invoking all the rules, requirements and necessary actions that would be called for by generation of one of the proprietary codes listed in Table 2.1.

Quality assurance is controlled for these general use codes through the local site/lab/facility software quality assurance program. Typically, each use of one of these codes is validated on an individual basis. Inputs to the code, the models employed, and the output are documented according to rules and guidelines specific to the site/lab/facility requirements when the results are to be applied. The level of detail and documentation applied is graded based on the level of complexity.

5.0 Lessons Learned and Recommendations

5.1 Lessons Learned

A survey has been completed for determining widely used, safety-related design software applied in the DOE Complex to support the analysis and design of defense nuclear facilities including structures, systems and components, as well electrical and control systems. From the responses to this survey, the following lessons learned are noted:

- Over seventy computer codes are used to support safety-related design functions.
- Fifteen of these codes are used by least two or more contractor organizations.
- Thirteen from this group of design software are used at two or more DOE sites.
- Most of the software is used for either civil/structural/geotechnical system analysis and design, or mechanical system analysis and design.
- There is no common software tool applicable to HVAC system design that is used at more than one site. The same is true for the instrumentation and control area.
- Nearly all of the fifteen computer codes are commercial-grade, proprietary software offered by United States-based software developers. The one exception is BlastX, a computer code for calculating blast overpressure, and developed and maintained by the U.S. Army Engineering Research and Development Center.
- Most of the software is updated on a frequent basis, on the order of one to two years.
- Nearly all of the codes in the multiple-use group have extensive, worldwide user communities. In a limited review of these code developers, most have a user-friendly internet website. Many of these sites provide newsletters, list online or remote training opportunities, and provide developer/user and user message boards. However, several codes' sites that appeared to offer little more than registration and callback opportunities.

The review of survey results and subsequent evaluation of the multiple-use design software was limited. However, it did reveal some indication of the level of formal compliance claimed to SQA standards. Six of the fifteen computer codes have Quality Assurance Plans and processes that are compliant with one or more of the following: 10 CFR 50 Appendix B, ISO 9001:2000 or ISO 9000-3. Only two, AutoPIPE and ETAP, claimed compliance with applicable parts of ASME NQA-1. More evaluation work is needed to confirm these levels of compliance.

Finally, it must be emphasized that no one computer code should be excluded from use at a specific site because it is not used elsewhere. If certain software is the best tool for a design or safety analysis purpose, and the user clearly understands the nature of the problem being modeled and the limitations of the code being applied, then that software should not be disallowed because other sites do not use it. Conceivably, the multiple-use code may result in an inferior performance compared to the single-site code in the use intended. Each safety analyst and design engineer is responsible for understanding the pedigree of the software they apply to each and every task, being appropriately trained, and obtaining sufficient peer review of their analyses.

5.2 Recommendations

Recommendations based on the outcome of the safety-related design software survey and interpretation of the lessons learned include the following:

1. **Toolbox Recommendation**: Safety-related design software is different from safety-related analysis software in its development, maintenance and application in the DOE Complex. Most of the software identified in the survey have worldwide user groups spanning many industries, have well-organized and comprehensive websites, and are commercially driven to minimize software deficiencies and provide corrective actions when identified. Based on this understanding, no design software is recommended for inclusion in the DOE Safety Software Toolbox.

2. **Design Software Links on a DOE Web-based information system**: A web-based information system is recommended to report design software issues on the part of DOE users, communicate lessons learned, and to promote dialogue with the software developers on fixes, new software versions, and training opportunities. The links could be set by use category as defined in the survey, i.e., civil/structural/geotechnical; mechanical; HVAC; electrical; fire protection; and I&C. A separate link would be available for the same purpose for general-use analytical software. While the multiple-use software identified earlier would be expected to be the basis for most of information "traffic" on each link, all software use would be included as long as it is applied in the use category of interest.

3. **Survey Updates:** While the survey reported herein is a good basis for decision-making on safety-related design software at this time, it is imperative that a survey of this nature be updated on a regular basis. Trends identified over the course of successive surveys would be invaluable in identifying problem areas or aspects of SQA protocol among developers, users, and DOE that may need attention. A survey update would help confirm whether changes in specific software have taken place, and if the composition of the list of fifteen computer codes identified through the 2003 "snapshot" should be changed. A survey could also evaluate the effectiveness of the DOE Web-based information system and the various design software links.

4. **SQA Standard Compliance**: While the multiple software developers appear to recognize the value of compliance with one or more of the SQA standards, there does not appear to be a set of minimum expectations that are clearly defined for each of the use categories. It is suggested that minimum requirements be developed by category and posted on the appropriate link in the DOE Web-based information system. In practice, the various categories could have the same set of standards, e.g. NQA-1, or ISO 9000, but some may also choose additional industry-specific standards.

6.0 Conclusion

A safety design code survey was completed per IP Commitment 4.2.1.5. The survey scope was within the DOE complex for facilities under major management of NA, EM, NE, and SC, and was limited to safety-related design software. The survey categorized software into seven major groups dependent on technical discipline or area, and was conducted over the October to December 2003 period. While several sites and organizations did not input to the survey, the trends and characteristics identified especially for multiple use software are believed to be representative of the DOE Complex, and would likely not be altered with the addition of inputs from the missing sites.

The survey results identify approximately seventy codes in the design arena. The survey also found that most of the software being used is proprietary. A significant number of the codes are site-specific codes (See Table 2.1 and A-2). Multiple sites/organizations use fifteen codes that are identified in Table 2.2. These are summarized in Table 6.1 below.

Table 6.1 Summary Table of Multi-use Design Codes

Survey of Design Codes - Multiple Use Codes		
Code Name	Number of Sites Using Code	Number of Organizations Using Code
1. ABAQUS	4	4
2. ANSYS	4	7
3. Autopipe	3	4
4. BlastX	2	2
5. COSMOS	2	2
6. ETAP	2	2
7. FLUENT	1	2
8. GTSTRDL	2	2
9. HASS	6	7
10. MicroShield	2	3
11. PIPE-FLO	1	2
12. RISA3D	2	2
13. SAP 2000	2	2
14. SASSI	3	4
15. SHAKE	3	3

These codes are used in industries outside of the Department of Energy Complex with most being widely distributed, used for multiple applications, and by many industries.

In contrast to the safety analysis toolbox codes, these codes generally:

- Are proprietary or controlled distribution codes
- Have general industry acceptance
- Have long standing use with successful histories
- Have extensive user groups
- Are commercially competitive (helps drive QA)
- Have critical use applications based on alternative methods (The results are not usually stand alone, but are supported in the context of the application by other means to assure quality.)

Based on the differences between the safety analysis toolbox codes and the design codes, it is concluded that a new software quality assurance strategy is needed for design codes.

For the design code software quality assurance strategy, no design codes are selected for the toolbox. The software quality assurance strategy for the design codes is dependent primarily on the fact that the design codes have been widely used, and have historically demonstrated acceptable quality. It is the user's responsibility to select the software version in a particular design application and justify its use. To centralize and streamline the software quality assurance process, several steps will be taken for the multiple-use design codes. DOE users will be invited to communicate user issues and supply other DOE application specific information on a web-based information system. Information on DOE specific applications and common quality problems can be shared in this way. Software developer-supplied information (including user group location and information, bug reporting, and training resources) can be provided to this web-based information system. Useful information exchange (on errors, defects, notices, upgrades) can be maintained and revised as needed on such a proposed system.

It is concluded that existing software quality assurance for the safety related design codes is adequate. However, some attention should be given towards identifying the industry standards that should be complied with in various categories of design software use. The web-based information system would be useful for posting this level of information for software developers and users alike.

A number of codes used in design are general-use/commercial off the shelf software. The survey has identified some of these codes such as Mathematica, MathCAD, and Excel. These codes have broad use worldwide. Use of these codes should be controlled though existing site/laboratory software quality assurance programs.

This survey is a snapshot in the October to December 2003 time frame of safety related design code usage in the DOE Complex. Although the survey was not responded to by all potential sites and organizations, the response was believed sufficiently large to base identification of trends and characteristics. As new codes are identified through the web-based information system, they may be used to determine if the current set should be modified.

It is the users' responsibility to assure appropriate software quality assurance is employed and implemented for each specific design code in a specific application. Users are responsible for

assuring that use of a specific code falls within the appropriate overall quality assurance plan at their DOE site or laboratory.

7.0 Acronyms and Definitions

ACRONYMS:

ABWR	Advanced Boiling Water Reactor
AEC	Architectural Engineering Construction
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ANSI	American National Standards Institute
AP600	Advanced Pressurized Reactor 600 Mega-Watts
ASME	American Society of Mechanical Engineers
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
COTS	Commercial Off-The-Shelf
CSI	Computers and Structures Inc.
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DSA	Documented Safety Analysis
EH	DOE Office of Environment, Safety and Health
EM	DOE Office of Environmental Management
GUI	Graphical User Interface
HVAC	Heating, Ventilation, and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers
IP	Implementation Plan
ISO	International Organization for Standardization
IV&V	Integrated Verification & Validation
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
NE	DOE Office of Nuclear Energy Science and Technology
NA	National Nuclear Security Administration
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
NQA	National Quality Assurance (standards)
OTI	Operations Technology Inc.
PLC	Programmable Logic Controller
QA	Quality Assurance
QAP	Quality Assurance Program (alternatively, Plan)
SASG	Safety Analysis Software Group
SBWR	Simplified Boiling Water Reactor
SC	Safety Class
SC	DOE Office of Science
SNL	Sandia National Laboratories
SQA	Software Quality Assurance
SSC	System Structure or Component
SRS	Savannah River Site
SRS	Software Requirements Specification
SS	Safety Significant
SVVP	Software Verification & Validation Plan

SVVR	Software Verification & Validation Report
V&V	Verification and Validation
WIPP	Waste Isolation Pilot Project
YMP	Yucca Mountain Project

DEFINITIONS:

The following definitions are taken from the Implementation Plan. References in brackets following definitions indicate the original source, when not the Implementation Plan.

Central Registry — An organization designated to be responsible for the storage, control, and long-term maintenance of the Department's safety analysis "toolbox codes." The central registry may also perform this function for other codes if the Department determines that this is appropriate.

Computer Code — A set of instructions that can be interpreted and acted upon by a programmable digital computer (also referred to as a module or a computer program).

Design Requirements — Description of the methodology, assumptions, functional requirements, and technical requirements for a software system.

Gap Analysis — Evaluation of the Software Quality Assurance attributes of specific computer software against identified criteria.

Independent Verification and Validation (IV&V) — Verification and validation performed by an organization that is technically, managerially, and financially independent of the development organization.

Safety Analysis and Design Software — Computer software that is not part of a structure, system, or component (SSC) but is used in the safety classification, design, and analysis of nuclear facilities to ensure proper accident analysis of nuclear facilities; proper analysis and design of safety SSCs; and proper identification, maintenance, and operation of safety SSCs.

Safety Analysis Software Group (SASG) — A group of technical experts formed by the Deputy Secretary in October 2000 in response to Technical Report 25 issued by the Defense Nuclear Facilities Safety Board (DNFSB). This group was responsible for determining the safety analysis and instrument and control (I&C) software needs to be fixed or replaced, establishing plans and cost estimates for remedial work, providing recommendations for permanent storage of the software and coordinating with the Nuclear Regulatory Commission on code assessment as appropriate.

Safety-Class Structures, Systems, and Components (SC SSCs) — SSCs, including portions of process systems, whose preventive and mitigative function is necessary to limit radioactive hazardous material exposure to the public, as determined from the safety analyses. [10 CFR 830]

Safety-Significant Structures, Systems, and Components (SS SSCs) — SSCs which are not designated as safety-class SSCs, but whose preventive or mitigative function is a

major contributor to defense in depth and/or worker safety as determined from safety analyses. [10 CFR 830] As a general rule of thumb, SS SSC designations based on worker safety are limited to those systems, structures, or components whose failure is estimated to result in prompt worker fatalities, serious injuries, or significant radiological or chemical exposure to workers. The term serious injuries, as used in this definition, refers to medical treatment for immediately life-threatening or permanently disabling injuries (e.g., loss of eye, loss of limb). The general rule of thumb cited above is neither an evaluation guideline nor a quantitative criterion. It represents a lower threshold of concern for which an SS SSC designation may be warranted. Estimates of worker consequences for the purpose of SS SSC designation are not intended to require detailed analytical modeling. Consideration should be based on engineering judgment of possible effects and the potential added value of SS SSC designation. [DOE G 420.1-1]

Safety Software — Includes both safety system software and safety analysis and design software.

Safety Structures, Systems, and Components (SSCs) — The set of safety-class SSCs and safety-significant SSCs for a given facility. [10 CFR 830]

Safety System Software — Computer software and firmware that performs a safety system function as part of a structure, system, or component (SSC) that has been functionally classified as Safety Class (SC) or Safety Significant (SS). This also includes computer software such as human-machine interface software, network interface software, programmable logic controller (PLC) programming language software, and safety management databases that are not part of an SSC but whose operation or malfunction can directly affect SS and SC SSC function.

Software — Computer programs, operating systems, procedures, and possibly associated documentation and data pertaining to the operation of a computer system. [IEEE Std. 610.12-1990]

Software Design Verification —The process of determining if the product of the software design activity fulfills the software design requirements. [NQA-1]

Source Code — A computer code in its originally coded form, typically in text file format. For programs written in a compilable programming language, the uncompiled program.

Toolbox Codes — A small number of standard computer models (codes) supporting DOE safety analysis, having widespread use, and of appropriate qualification that are maintained, managed, and distributed by a central source. Toolbox codes meet minimum quality assurance criteria. They may be applied to support 10 CFR 830 DSAs provided the application domain and input parameters are valid. In addition to public domain software, commercial or proprietary software may also

be considered. In addition to safety analysis software, design codes may also be included if there is a benefit to maintain centralized control of the codes [modified from DOE N 411.1].

Validation — Assurance that a model as embodied in a computer code is a correct representation of the process or system for which it is intended. This is usually accomplished by comparing code results to either physical data or a validated code designed to perform the same type of analysis. [IEEE-610.12]: The process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements. Contrast with: **verification**.

Verification — Assurance that a computer code correctly performs the operations specified in a numerical model or the options specified in the user input. This is usually accomplished by comparing code results to a hand calculation or an analytical solution or approximation. [IEEE-610.12]: (1) The process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. Contrast with: **validation**. (2) Formal proof of program correctness.

8.0 References

CFR Code of Federal Regulations (10 CFR 830). 10 CFR 830, Nuclear Safety Management Rule.

DNFSB Defense Nuclear Facilities Safety Board, (2000). *Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities*, Technical Report DNFSB/TECH-25, (January 2000).

DNFSB Defense Nuclear Facilities Safety Board, (2002). *Recommendation 2002-1, Quality Assurance for Safety-Related Software* , (September 2002).

DOE, U.S. Department of Energy (2000a). *Appendix A, Evaluation Guideline,* DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Reports* (January 2000).

DOE, U.S. Department of Energy (2000b). *Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities*, DOE Response to TECH-25, Letter and Report, (October 2000).

DOE, U.S. Department of Energy (2002). *Selection of Computer Codes for DOE Safety Analysis Applications* (August 2002).

DOE, U.S. Department of Energy (2003a). *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2002-1: Quality Assurance for Safety Software at Department of Energy Nuclear Facilities*, Report, (March 13, 2003).

DOE, U.S. Department of Energy (2003b). *Designation of Initial Safety Analysis Toolbox Codes*, Letter, (March 28, 2003).

DOE, U.S. Department of Energy (2003c). *Assessment Criteria and Guidelines for Determining the Adequacy of Software Used in the Safety Analysis and Design of Defense Nuclear Facilities*, Report, CRAD-4.2.4-1, Rev 0, (August 27 2003).

DOE, U.S. Department of Energy (2003d). *Software Quality assurance Improvement Plan: Format and Content For Code Guidance Reports*, Revision A (draft), Report, (August 2003).

DOE, U.S. Department of Energy (2003e). *Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes*, (draft), Report, (September 2003).

DOE, U.S. Department of Energy (2003f). MACCS2 Computer Code Application Guidance for Documented Safety Analysis, (draft), Report, (September 2003).

Appendices

Appendix	Subject
A	Site/Organization and Software Use by Design Category
B	Information Summaries Related To Multiple-Use Safety Design Codes Identified In The Survey

APPENDIX A.- Site/Organization and Software Use by Design Category

Table A-1 provides the same survey information as Table 2.1, but reorders the table to show site/organization by row and by category in the columns.

Footnotes to Table
[1] Multiple codes used to model the performance of the WIPP repository, not used for safety.

	Table A-1. Site/Contractor and Software Used by Design Category							
	Category							
Site/ Organization	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
SRS	ABAQUS	ANSYS	None	PDMS	HASS	None	VERSE-LC	
	GTSTRUDL	Autopipe Plus		ETAP				
	SHAKE91	Type II, III, & IIIA Tank Top Load,						
	SASSI	MSC/THERMAL						
	SRPP	ABAQUS						
WIPP	None	None	None	None	None	None	None	CAP88-PC V1.0
								GEN-II-s
								MetData Application
								RadClient/Radnet
								Lpu02af.exe
								Lpu02.ab.exe
								ALGEBRACDB,BLOTCDB,BRAGFLO,CCD2STEP,…. etc.[1]
								GXQ
Rocky Flats	None	None	None	None	HASS	None	RADIDOSE	

	Table A-1. Site/Contractor and Software Used by Design Category							
Site/ Organization	**Category**							
	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
					FAST			
Yucca Mtn.								MACCS2 Version 1.12
ANL-W	SAP2000	ALGOR			HASS	DMT	Micro-Shield	
	Nonlinear					ARCS		
	ALGOR							
Hanford/CH2M Hill	ANSYS/Mech. Version 7.0	AutoPIPE	GOTH-SNF				Micro-Shield 6.01	
Hanford/Bechtel National	ANSYS	Aspen BJAC 11.1	FLUENT	AGI32 Version 1.64	HASS 7.5	Control Valve Sizing - Gas Service Version 1.1	WTP Engr. Baseline	MATHCAD 11
	CE980 (BSIMQKE),1984	Compress 6.187/6.214		ETAP POWERSTATION 4.7.0		Control Valve Sizing - Liquid Service Version 1.1	Process Perf. SW 1.0	Mathematica
	Compress 6.187/6.214	DAPSS 1.0		EA399/Setroute Version 8.7.1.1		Control Valve Sizing - Steam Service Version 1.1	Micro Shield 6.0.1	MCNP 4C
	CE928 (DATAN),	FLUENT				FLOWEL, Version 3.0g	HSC Chemistry 4.1	

	Table A-1. Site/Contractor and Software Used by Design Category							
Site/ Organization	**Category**							
	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
	1991							
	GTSTRUDL Version 25	HTRI (IST 2.0) (PHE 2.0)					Delmia Envision Version D5R12 (IGRIP)	
	SASSI 2000	B31.3/Multiple Mes & versions					winnUPRA Version 2.0	
	SHAKE 2000	Jet Impingement Code (NE155)						
		Pipe-Flo compressible Version 7.0						
		Pipe-Flo Professional Version 7.0						
Hanford/Duratek	ANSYS	FLUENT/GAMBIT		PTW				MCNP ORIGEN
	Flex PDE							
	LS-DYNA and LS-POST							
	Ansoft Mawell 3_d							

	Table A-1. Site/Contractor and Software Used by Design Category							
Site/ Organization	**Category**							
	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
	0							
Sandia	ABAQUS 6.3	COSMOS 2.8					Integrated Tiger Series V5.0	MACCS 2
	COSMOS 2.8						ADEPT	MELCOR
							ANITA V2000	MCNP V5.0
							CINDER V90	
							DKPOWR	
							PARTISN V2.9	
							SCALE V4.4A	
LANL	Sap 2000 NL	AutoPipe Plus 6.3			HASS			MATHCAD
	ETABS NL	AFT Fathom 5.0						MASS
	SAFE	COSMOS/M 2.6						SQ LIMS V3.1
	RISA3D	DESIRE 2000						Transient Combustible EXCEL Spdsheet V2.1

	Table A-1. Site/Contractor and Software Used by Design Category							
Site/ Organization	**Category**							
	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
	ABAQUS							MAR Summary032701 V1.0.0.1
	SHAKE91							CFAST/FAST 5.01 3.1.7,2.01
	SASSI							SANET
	BlastX							POSTMAX2
	ANSYS V7.1							SeaTREE
	PSADS							FDS2
								ERAD 3.2
								CAMEOfm
								AutoDesk AutoCad
								MARPLOT V3.3
								EPIcode 6.01,MACCS2, GENII 2, MELCOR, HOTSPOT 2.05
								ALOHA V5.3.2
								DANTSYS
								MCNPx, MCNP-4C

	Table A-1. Site/Contractor and Software Used by Design Category							
	Category							
Site/ Organization	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
Pantex	ANSYS V7.1	ANSYS 7.1	Trace 700 V4.0	SKM Power Tools	HASS			MCNP 4A,4B,4C,5 AND X
	BlastX V4.2							SOURCES-4C
	STADD Pro 2003							TWODANT
	MSC MARC 2003, Dytran 2002, Nastran 2003							SAFER V.202
	Pro-Engineer 2001							MSC Patran 2003
								ERAD
								NARAC
								MSC ADAMS 2003, Mvision
								SABRINA
								MACCS 2, MELCOR, HOTSPOT 2.0, EPIcode 2.03, ALOHA
								KENO V & KENO -3D
								VISUAL EDITOR

	Table A-1. Site/Contractor and Software Used by Design Category							
Site/ Organization	**Category**							
	Civil/Structural/ Geotechnical	Mechanical Systems	HVAC	Electrical Systems	Fire Protection	Instrumentation and Control	Other Design Software	Other Software-Not Recommended As Design
LLNL								HOTSPOT V2.05
DOE Richland	VAM3DF	AutoPipe			HASS			MATLAB
	ABAQUS	Pipe-Flo						
	SASSI							
	ANSYS							
	SAP2000 Plus							
	SAP Nonlinear							
	WaterCAD							
`	RISA3D							

APPENDIX B.— Information Summaries Related To Multiple-Use Safety Design Codes Identified In The Survey

Introduction

Table 2.2 of the main text identifies the codes from the survey that are used at more than one site, or by more than one organization (multiple-use codes). This Appendix presents brief one-page descriptions of each code. Contact information is provided. A synopsis based on web information available is provided concerning the quality assurance status of each code.

Table B-1. ABAQUS

a.	**Area of Applicability**	Civil/Structural/Geotechnical Systems;
b.	**Code name and version(s)**	ABAQUS
c.	**Function of code**	ABAQUS provides solutions for linear, non-linear, explicit and multi-body dynamics problems to deliver a unified finite element analysis environment. The ABAQUS suite consists of three core products - ABAQUS/Standard, ABAQUS/Explicit and ABAQUS/CAE. Each of these packages offers additional optional modules that address specialized capabilities some customers may need. **ABAQUS/Standard®**, provides ABAQUS solver technology to solve traditional implicit finite element analyses, such as static, dynamics, thermal, all powered with the widest range of contact and nonlinear material options. ABAQUS/Standard also has optional add-on and interface products with address design sensitivity analysis, offshore engineering, and integration with third party software, e.g., plastic injection molding analysis. **ABAQUS/Explicit®**, provides ABAQUS solver technology focused on transient dynamics and quasi-static analyses using an explicit approach appropriate in many applications such as drop test, crushing and many manufacturing processes. **ABAQUS/CAE®**, provides a complete modeling and visualization environment for ABAQUS solvers. With direct access to CAD models, advanced meshing and visualization, and with an exclusive view towards ABAQUS solvers, ABAQUS/CAE is the modeling environment of choice for ABAQUS solvers.
d.	**Software Developer/Owner; Contact Information**	ABABAQUS, Inc., 1080 Main Street, Pawtucket, Rhode Island 02860-4847 Tel: 401 727 4200; Fax: 401 727 4208 E-mail: info@abaqus.com; http://www.abaqus.com/contact.html Technical support: support@abaqus.com
e.	**SQA Standard(s) Cited**	Quality assurance is stated to meet the ISO 9001 standard. However, vendor indicates QA Plan allows providing software that conforms to the US Nuclear Regulatory Commission's quality assurance requirements and may thus be used for calculations associated with the licensing of nuclear power facilities in the USA.
f.	**Training/User-Developer Interaction**	ABAQUS and its representatives offer regularly scheduled public seminars as well as training seminars at customer sites. An extensive range of seminars is available, ranging from basic introductions to advanced seminars, which cover specific analysis topics and applications. Three times a year ABAQUS Insights newsletter is published. Since 1988, each year in late spring, ABAQUS Inc.hosts the annual worldwide ABAQUS Users' Conference. ABAQUS employs over 350 people worldwide, with over 24 direct offices providing technical support, sales, and services and with a network of technically advanced distributors in emerging markets.
g.	**Estimated Number of Users**	Worldwide

Table B-2. ANSYS

a.	**Area of Applicability**	Civil/Structural/Geotechnical Systems; Mechanical;
b.	**Code name and version(s)**	ANSYS
c.	**Function of code**	ANSYS is structural analysis software. Its structural models have a full complement of nonlinear elements, nonlinear and linear material laws, and inelastic material models. ANSYS simulates the largest and most intricate of structures. Its nonlinear contact functionality allows for the analysis of complicated assemblies. ANSYS offers users an intuitive, tree-structured GUI for easy definition of even the most intricate material models and a choice of iterative and direct solvers for optimal. ANSYS mechanical models include a full complement of nonlinear and linear elements, material laws ranging from metal to rubber, and a comprehensive set of solvers. The mechanical models can handle very complex assemblies—for example, those involving nonlinear contact—and is used for determining stresses, temperatures, displacements and contact pressure distributions on component and assembly designs.
d.	**Software Developer/Owner; Contact Information**	ANSYS, Inc. Southpointe 275 Technology Drive Canonsburg, PA 15317 ansysinfo@ansys.com T 724.746.3304 F 724.514.9494 Toll Free USA and Canada: 1.866.ANSYS.AI (1.866.267.9724) Home Page: http://www.ansys.com/index.htm
e.	**SQA Standard(s) Cited**	ANSYS, Inc. is claimed to be the first developer of simulation software to obtain ISO 9001:2000 certification, the internationally accepted quality standard for the software industry.
f.	**Training/User-Developer Interaction**	Training courses are provided on a regular basis and newsletters are issued.
g.	**Estimated Level of Use**	Worldwide.

Table B-3. BLASTX

a.	**Area of Applicability**	Civil/Structural/Geotechnical Analysis
b.	**Software name and version(s)**	BLASTX
c.	**Function of Software**	BLASTX is a code developed by the Army Corps of Engineers Energy and Research Development Center that calculates blast overpressure. It accurately computes both the positive and negative phases of the shock wave. BLASTX (version 3.0) code calculates the propagation of blast shock waves and detonation product gases in multi-room structures. The code provides predictions of the pressure-time and temperature-time histories in these structures. The 3.0 version includes: (1) a variety of room shapes that may be used throughout a structure, (2) an interactive menu-driven input module, (3) an enhanced version of the burning, venting, and wall-failure models from the Naval Surface Warfare Center INBLAST code, (4) failure models using the total shock and quasi-static gas pressure on a wall, (5) heat conduction to walls, (6) a more accurate model of shock propagation through openings, and (7) modeling of blast-effects within and outside of explosive storage magazines. The code uses dynamic memory allocation so that structures ranging from a single room to many rooms may be treated. .
d.	**Software Developer/Owner; Contact Information**	U.S. Army Engineer Research and Development Center Geotechnical and Structures Laboratory 3909 Halls Ferry Road Vicksburg, MS 39180-6199 No website information is available.
e.	**SQA Standard(s) Cited**	No SQA information has been identified.
f.	**Training/User-Developer Interaction**	-No Training/User-Developer Interaction Information is available.
g.	**Estimated Level of Use**	Unknown.

Table B-4. GTStrudl

a.	**Area of Applicability**	Civil/Structural/Geotechnical Systems
b.	**Software name and version(s)**	GT STRUDL
c.	**Function of Software**	GT STRUDL is a Structural Design & Analysis software program for Architectural - Engineering - Construction (AEC), CAE/CAD, utilities, offshore, industrial and civil works. GT STRUDL is a fully integrated general- purpose structural information processing system capable of supplying an engineer with accurate and complete technical data for design decision-making. GT STRUDL integrates graphical modeling and result display, frame and finite static, dynamic, and nonlinear analysis, finite element analysis, structural frame design, graphical result display, and structural database management into a menu driven information processing system. In over 25 years of use, GT STRUDL has become a widely accepted Computer-Aided Engineering and Design tools for the structural analyst and structural design engineer.
d.	**Software Developer/Owner; Contact Information**	**GT STRUDL** Georgia Tech - CASE Center 790 Atlantic Drive Atlanta, Georgia 30332-0355 USA Phone: (404) 894-2260; FAX: (404) 894-8014 E-mail: casec@ce.gatech.edu Home Page: http://www.gtstrudl.gatech.edu/
e.	**SQA Standard(s) Cited**	The vendor claims that GT STRUDL is validated and certified in full conformance to the applicable provisions of the United States Nuclear Regulatory Commission software quality assurance and quality control regulations. Additionally, it is stated that GT STRUDL support and quality assurance standards offered by the Georgia Tech - CASE Center are among the most rigorous in the industry. GT STRUDL software certification procedures are in full conformance with the applicable provisions of the U.S. Nuclear Regulatory Commission quality assurance and quality control regulations (10CFR-50, Appendix B), and ISO9000-3. Full-service support provided by the CASE Center includes software verification and certification, quality control and assurance, program updates, enhancements, performance improvements, and telephone hot- line support (providing installation assistance, systems support, and advice on the effective uses of GT STRUDL.
f.	**Training/User-Developer Interaction**	Training and seminars on using of GTSTRUDL are provided.
g.	**Estimated Level of Use**	Worldwide: GT STRUDL is used on a regular basis by thousands of engineers in over 30 countries.

Table B-5. RISA-3D

a.	**Area of Applicability**	Civil/Structural/Geotechnical Analysis
b.	**Software name and version(s)**	RISA-3D
c.	**Function of Software**	RISA-3D for Windows is a general purpose three-dimensional analysis and design program developed to make the definition, solution and modification of 3D problem data as fast and easy as possible. Complete hot rolled steel, cold formed steel, and wood design is included. Analysis, up to and including calculation of maximum deflections and stresses, may be done on structures constructed of any material or combination of materials. This program is based on the widely accepted Linear Elastic Stiffness method for model solution. The stiffness of each element of the structure is calculated independently. These stiffnesses are then combined to produce the model's overall (global) stiffness matrix. This global matrix is then solved (versus the applied loads to calculate joint deflections.) These joint deflections are then used to calculate the individual element stresses. The dynamic analysis is performed using a subspace iteration procedure.
d.	**Software Developer/Owner; Contact Information**	RISA Technologies 26632 Towne Centre Drive, Suite 210 Foothill Ranch, CA 92610 United States of America Voice: (949) 951-5815 (local & international) Toll Free: (800) 332-RISA (inside the US) Fax: (949) 951-5848 E-mail: info@risatech.com Home Page: : http://www.risatech.com/default.asp
e.	**SQA Standard(s) Cited**	The RISA Technology site has an error and bug-reporting page. The site lists technical frequently asked questions. No other QA specific information was found on the web site.
f.	**Training/User-Developer Interaction**	Training courses are offered by RISA Technologies.
g.	**Estimated Level of Use**	Appears extensive, but could not be confirmed

Table B-6. SAP2000

a.	**Area of Applicability**	Civil/Structural/Geotechnical Analysis
b.	**Software name and version(s)**	SAP2000
c.	**Function of Software**	SAP2000 provides three dimensional static and dynamic finite element analysis and design of structures. The intuitive interface allows creation of structural models rapidly and intuitively without long learning curve delays. Complex models can be generated and meshed with powerful templates built into the interface. The advanced analytical techniques allow for step-by-step large deformation analysis, multiple p-delta, eigen and ritz analyses, cable analysis, tension or compression only analysis, buckling analysis, blast analysis, fast nonlinear analysis for dampers, base isolators and support plasticity, energy methods for drift control and segmental construction analysis.
d.	**Software Developer/Owner; Contact Information**	Computers & Structures, Inc. (CSI) Telephone Number: 510-845-2177 E-Mail Address: baser@comp-engineering.com Home Page: http://www.csiberkeley.com/SAP2000_Software.html
e.	**SQA Standard(s) Cited**	SAP 2000 Version 8.0 has a new QA program in place with a new verification manual. A verification document provides example problems used to test various features and capabilities of the SAP2000 program. The problems demonstrate the adequacy of the program for use in all applications, including safety-related nuclear, as governed by 10CFR50 requirements as well as other international QA standards, such as ISO 9000:2000 requirements.
f.	**Training/User-Developer Interaction**	Tutorials are provided on the web and training is scheduled by CSI on a regular basis.
g.	**Estimated Level of Use**	Unknown

Table B-7. SASSI

a.	**Area of Applicability**	Civil/Structural/Geotechnical Systems
b.	**Software name and version(s)**	SASSI
c.	**Function of Software**	SASSI (a System for Analysis of Soil-Structure Interaction) was originally developed by a group of graduate students at the University of California, Berkeley. SASSI2000 is a package of interrelated computer programs that can be used to solve a wide range of dynamic soil-structure interaction problems in two or three dimensions. SASSI has been used by many engineering firms and other institutions for dynamic soil-structure interaction analysis. It is currently an industry standard for solving soil-structure interaction problems. The seismic design of all standard nuclear power plants in the United States (ABWR, SBWR, AP600, and System 80+) and many of the older plants is based on the SASSI solution for generation of seismic responses. SASSI is increasingly used in other industries including transportation, petrochemical, and industrial facilities when subjected to dynamic loading.
d.	**Software Developer/Owner; Contact Information**	SASSI2000 2 Agnes St Oakland CA 94618-2523 USA Fax number for Registration: (510) 652 2958 Account enquiries: accounts@sassi2000.com Information enquiries about SASSI2000: info@sassi2000.com Home Page: http://www.sassi2000.com
e.	**SQA Standard(s) Cited**	The site has a discussion forum and manuals. No other QA information was found on the web site. In the recent soil-structure interaction field experiment in Lotung, Taiwan, SASSI was one of the most successful programs to predict the response of the containment model and its components.
f.	**Training/User-Developer Interaction**	Tutorials are provided on the website for training.
g.	**Estimated Level of Use**	Worldwide.

Table B-8. SHAKE

a.	**Area of Applicability**	Civil/Structural/Geotechnical Analysis
b.	**Software name and version(s)**	SHAKE
c.	**Function of Software**	SHAKE is software for equivalent linear seismic response analysis of horizontally layered soil deposits. It is developed and supported by the University of California. The SHAKE program has been a widely used program for computing the seismic response of horizontally layered soil deposits. The program computes the response of a semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves. The analysis is done in the frequency domain, and, therefore, for any set of properties, it is a linear analysis. An iterative procedure is used to account for the nonlinear behavior of the soils. The object motion (i.e., the motion that is considered to be known) can be specified at the top of any sub layer within the soil profile or at the corresponding outcrop. Manuals source code and information can be found through the National Information Service for Earthquake Engineering, University of California, Berkeley.
d.	**Software Developer/Owner; Contact Information**	National Information Service for Earthquake Engineering University of California, Berkeley EERC Library 1301 S. 46th Street Richmond, CA 94804-4698 Phone: 510-231-9403 Fax: 510-231-9461 Email: eerclib@nisee.berkeley.edu Home Page: http://nisee.berkeley.edu/software/shake91
e.	**SQA Standard(s) Cited**	No SQA information has been identified.
f.	**Training/User-Developer Interaction**	Unknown, Online manuals available.
g.	**Estimated Level of Use**	Unknown

Table B-9. AutoPIPE

a.	**Area of Applicability**	Mechanical
b.	**Software name and version(s)**	AutoPIPE
c.	**Function of Software**	AutoPIPE is a computer aided engineering program for stress analysis of piping systems. AutoPIPE enables engineers to explore different alternatives for piping design and perform code compliance checks in a time and cost efficient manner. AutoPIPE contains a comprehensive and extensible library of material properties and piping components including pipes, reducers, tees, valves, flanges, flexible connectors and other items. It performs single and multiple spring hanger design for one or more operating conditions. The code performs linear or nonlinear static analysis of piping systems and their supports. The software's proven nonlinear algorithm solves complex problems containing gaps, friction, buried pipe, limit stops, and other piping configurations. Loading includes gravity, buoyancy, support displacements, point and distributed loads, thermal expansion, pressure thrust, equivalent static earthquake, wave, and wind loadings.
d.	**Software Developer/Owner; Contact Information**	Bentley Systems, Inc. 685 Stockton Drive Exton, PA 19341 1-800-BENTLEY or +1 610 458 5000 Home Page: http://www.bentley.com/products/disciplines/plant/engineering/autopipe/ Contact site: http://www.bentley.com/tools/sales.cfm?product=AutoPIPE
e.	**SQA Standard(s) Cited**	The vendor claims that AutoPIPE's rigorous quality assurance program has passed numerous independent on-site audits to 10CFR50 App. B, ASME NQA-1, and ANSI N45.2 standards. Bentley has formally written and approved test plans for verification of every modification and new feature to AutoPIPE as well as integration testing for features implemented in previous versions with records of validation spanning more than six years. Users can receive formal error reports that classify errors based on severity, an explanation of the implications of each error, and known workarounds..
f.	**Training/User-Developer Interaction**	Training is provided for the code by a number of vendors.
g.	**Estimated Level of Use**	Worldwide.

Table B-10. COSMOS

a.	**Area of Applicability**	Civil/Structural/Geotechnical Systems; Mechanical
b.	**Software name and version(s)**	COSMOS
c.	**Function of Software**	COSMOSM™ is one of a series of COSMOS modules that offer a wide range of analysis capabilities, including: • Modeling, meshing and visualization of parts as well as assemblies • Comprehensive analysis capabilities, stress, frequency, displacement, buckling, heat transfer, nonlinear, dynamic response and fatigue capabilities; and • Design optimization. COSMOSM features an extensive library of 1D, 2D and 3D elements supports isotropic, orthotropic, anisotropic, multi-layer composite, and temperature-dependent material properties. Capabilities include linear gap/contacts, stress stiffening, sub-structuring, multi-point constraints, constraint equations and more. COSMOSM can solve the computation of heat transfer due to conduction, including with convection and radiation boundary condition, for materials with isotropic, orthotropic, composite, and temperature-dependent properties. It can perform nonlinear analyses.
d.	**Software Developer/Owner; Contact Information**	Structural Research & Analysis Corp. 12121 Wilshire Blvd. Suite 700 Los Angeles, CA 90025 Phone: 310.207-2800 Fax: 310.207-2774 E-mail: info@srac.com Home Page: http://www.cosmosm.com/pages/products/cosmosm.html
e.	**SQA Standard(s) Cited**	Not apparent. The web site allows for feedback and error reporting. A newsletter for the product is offered. Frequently asked questions for running the code are posted on the site.
f.	**Training/User-Developer Interaction**	Training packages are offered through Structural Research & Analysis Corporation. Some are available “online”.
g.	**Estimated Level of Use**	Worldwide.

Table B-11. FLUENT

a.	**Area of Applicability**	Mechanical Analysis; HVAC Analysis
b.	**Software name and version(s)**	FLUENT
c.	**Function of Software**	FLUENT is a computational fluid dynamics (CFD) code used to resolve a wide range of problems. It has unique capabilities in an unstructured, finite volume based solver. It is coupled with pre-processing and post-processing software offered by FLUENT Inc. Some of its features include: Complete mesh flexibility; All speed regimes (low subsonic, transonic, supersonic, and hypersonic flows); Parallel processing; Solution-based mesh adaption; Steady-state and transient flows; Inviscid, laminar, and turbulent flows; Newtonian or non-Newtonian flows; Full range of turbulence models from simple k-epsilon models to large eddy simulation; Heat transfer including forced, natural, and mixed convection, conjugate heat transfer, as well as several radiation models; Chemical species transport and reaction, including homogeneous and heterogeneous combustion models and surface reaction models; Free surface, Eulerian and mixture multiphase models; Lagrangian trajectory calculation for dispersed phase modeling (particles/droplets/bubbles); Phase change model for melting/solidification applications; Cavitation model; Materials property database; Integrated problem set-up and post-processing; and Extensive customization via user-defined functions.
d.	**Software Developer/Owner; Contact Information**	FLUENT USA 10 Cavendish Court, Centerra Park Lebanon, New Hampshire 03766 Phone: (603) 643-2600 Fax: (603) 643-3967 Home Page: http://www.fluent.com/ http://www.fluent.com/worldwide/usa/about/nh.htm
e.	**SQA Standard(s) Cited**	FLUENT's quality management system is now registered to the ISO 9001:2000 international standard and TickIT. FLUENT has chosen the widely recognized ISO 9001 standard for quality assurance and the TickIT scheme for software development organizations as the basis for a quality management system. ISO 9001 applies to businesses that are involved in design, development, production, installation, and servicing. The TickIT scheme contains guidelines for applying ISO 9001 requirements specifically to software industries.
f.	**Training/User-Developer Interaction**	-Consulting and University Program Information is available from website; Some initial training is offered with original license.
g.	**Estimated Level of Use**	- Worldwide.

Table B-12. PIPE-FLO

a.	**Area of Applicability**	Mechanical System Analysis
b.	**Software name and version(s)**	Pipe-Flo
c.	**Function of Software**	PIPE-FLO Professional provides a picture of the entire piping system by integrating the following tasks into a single program: 1)A flow diagram interface showing how the system components and pipelines are connected, 2)A powerful calculation engine showing how the system operates, 3)Communication tools to share the design with others, 4)Links to supporting documents in electronic format. PIPE-FLO draws a piping system schematic or FLO-Sheet showing all the pumps, components, tanks, control valves and interconnecting pipelines. It sizes the individual pipelines using electronic pipe, valve, and fluid data tables. It selects pumps and control valves from manufacturer's Electronic Catalogs, to optimize pump and system operation. PIPE-FLO calculates how the system operates including pressures and flow rates, net positive suction head, and annual operating costs. It creates FLO-Links to provide immediate access to supporting documents needed to design, build and operate the piping system. The user can share the piping system information with others by way of the PIPE-FLO Viewer.
d.	**Software Developer/Owner; Contact Information**	Engineered Software, Inc. 4531 Intelco Loop SE Lacey, WA 98503-5941 Sales - (800) 786-8545 Technical Support - (360) 412-0702 opt. 4 Office - (360) 412-0702 Fax - (360) 412-0672 Home Page: http://www.eng-software.com/pro.htm
e.	**SQA Standard(s) Cited**	A newsletter is provided. Technical information on the code is provided at the site. No other QA information was found on the web site.
f.	**Training/User-Developer Interaction**	Training on the software is provided by Engineered Software.
g.	**Estimated Level of Use**	Engineered Software indicates that the software is used in 20 different industries with over 15,000 customers.

Table B-13. ETAP

a.	**Area of Applicability**	Electrical Systems
b.	**Software name and version(s)**	ETAP
c.	**Function of Software**	ETAP PowerStation is a fully integrated electrical power system analysis tool. Over 50,000 engineers use PowerStation worldwide in the design, analysis, maintenance, and operation of electrical power systems. ETAP PowerStation offers a wide selection of modules including: panel systems, short-circuit, load flow, motor acceleration, transient stability, generator start-up, harmonic analysis, etc.
d.	**Software Developer/Owner; Contact Information**	OTI Inc. 17 Goodyear Irvine, CA 92618-1812 (949) 462-0100 (800) 477-ETAP Fax: (949) 462-0200 Home Page: :www.etap.com
e.	**SQA Standard(s) Cited**	PowerStation is developed under an established quality assurance program and is being used in the majority of high-impact nuclear facilities in the United States. OTI's commitment to providing the highest quality product in the marketplace is thoughtfully executed through the ETAP Quality Assurance program, first implemented in 1991. The Quality Assurance Plan has since been expanded and enhanced to comply with the following widely accepted and firmly established standards: United States Code of Federal Regulations, 10 CFR 50, Appendix B, 10 CFR 21, ANSI/ASME N45.2-1977, ASME NQA-1 (Including Subpart 2.7), ISO 9001 Standard, ANSI/IEEE Std 730.1-1989, CAN/CSA-Q396.1.2. When purchased as a 'Safety-Related' (High-Impact) Nuclear version, the ETAP package is accompanied by the following: · Certification Letter, Software Requirements Specification (SRS), Software Verification & Validation Plan (SVVP), Software Verification & Validation Report (SVVR), Test Files & Output Report Files in an Electronic Format, and Opportunity to Audit & Assess OTI's Quality System.
f.	**Training/User-Developer Interaction**	Training packages are offered through Structural Research & Analysis Corporation. Some are available "online".
g.	**Estimated Level of Use**	Worldwide. Over 50,000 engineers use PowerStation worldwide in the design, analysis, maintenance, and operation of electrical power systems.

Table B-14. HASS

a.	**Area of Applicability**	Fire Protection
b.	**Software name and version(s)**	HASS
c.	**Function of Software**	HASS (Hydraulic Analyzer of Sprinkler Systems) was introduced in 1976 and has been upgraded annually. The code operates with all versions of Windows in English or metric units as well as metric units with Spanish text. Data entry features include a grid estimator, tree generator, system builder and utilities to develop equivalents for K-factors, branch lines, grids and fitting lengths. Other utilities calculate earthquake bracing, report flow results, analyze water hammer, and more. HASS calculates complex systems in seconds using either the Hazen-Williams or the Darcy-Weisbach formulas, with or without velocity pressure. HASS performs hydraulic analysis in accordance with NFPA 13, calculating any connection of nodes and pipes.
d.	**Software Developer/Owner; Contact Information**	HRS Systems Phone: 770.934.8423 fax 770.934.7696 hass@hrssystems.com http://www.hrssystems.com/index.html
e.	**SQA Standard(s) Cited**	Users are supplied with updates and code revisions annually. No other quality assurance data on the code was found on the web site.
f.	**Training/User-Developer Interaction**	No training was discussed on the web site. The web site states most HASS users have experience in sprinkler system design, layout or review. HASS was designed for those with sprinkler knowledge and capable of making value judgments concerning the calculations.
g.	**Estimated Level of Use**	Vendor reports the code is used by thousands in over fifty countries.

Table B-15. MicroShield

a.	**Area of Applicability**	Other: Radiological Shielding
b.	**Software name and version(s)**	MicroShield
c.	**Function of Software**	MicroShield is a comprehensive photon/gamma ray shielding and dose assessment program being used by more than 500 organizations. It is widely used for designing shields, estimating source strength from radiation measurements, minimizing exposure to people, and teaching shielding principles. Its use requires a basic knowledge of radiation and shielding principles. It was originally developed by Grove Engineering, which was acquired by Framatome ANP.
d.	**Software Developer/Owner; Contact Information**	Framatome ANP Grove Engineering 3416 Olanwood Court Suite 211 Olney, Maryland (301) 929-3028 Fax (301) 929 3047 http://www.framatech.com/radsoft/radsoft.asp
e.	**SQA Standard(s) Cited**	MicroShield has a verification and validation package available. The overall purpose of the V&V package is to furnish documentation and software as an aid to users in their internal software qualification or verification and validation. The V&V package includes a two-part "MicroShield Verification & Validation Report". This report consolidates a myriad of information sources used over the years for development of MicroShield. It also shows the mathematical basis for all the calculations performed by the program. In general, it is a complete compendium of the technical bases for MicroShield. Part I of the report contains the V&V test plan and results and the user instructions for VNV.EXE. Part II contains the mathematical formulation for the calculations. Historical test results are included in appendices for traceability and completeness.
f.	**Training/User-Developer Interaction**	Training is discussed on the web site.
g.	**Estimated Level of Use**	Widely used by more than 500 organizations.